ENCLOSURE #3

UAi submitts for FBIS approval the proposed and recommended on site 3 day training program recommended by ESI, for up to 4 people, in their letter 20 June 84 to John Wallace. Course to be accomplished after on site acceptance test.

Cost to FBIS is $ 3959.00

Training Course	$ 2600.00
ESI Expenses 3 days	330.00
	$ 2930.00
UAi burden 1.175 x 1.15	$3959.00

ELECTROSPACE SYSTEMS, INC.

20 June 1984
84-CAD/RCF-1528

Universal Antennas, Inc.
909 East Collins Blvd.
Suite 101
Richardson, TX 75081

Attention: [redacted] STAT

Subject: Training Class, Reliability Analysis - FBIS Antenna Control Systems

Reference: UAI Purchase Order 13823

Gentlemen:

In response to your requests for pricing on training classes and information on system reliability, we have prepared a brief summary.

Costs for training in conjunction with the installation are $2,600.00 and expenses plus 30%. This includes three days of labor for system training to the board level and training materials for up to four (4) people. Topics included will be:

Equipment Operation
Troubleshooting to Assembly Level
Use of Spare Parts (Purchased)
Use of Manuals
Fault Emulation and Detection

This type of training will be beneficial to maintenance personnel irrespective of their previous backgrounds in integrated circuit and control loop electronics.

At your request, a copy of a standard system reliability analysis is enclosed. Please consider section 2.0 of the analysis where trained maintenance personnel and 100% spare parts inventory are assumed as essential components in validating our maintainability figures.

P.O. BOX 1359 • RICHARDSON, TEXAS 75080 • (214) 231-9303 • TWX 910-867-4768

If you have further questions concerning these matters, please contact Chuck Dade, Tom Scanio or the undersigned.

Sincerely,

ELECTROSPACE SYSTEMS, INC.

STAT

Vice President

CAD/RCF:jt
Enclosure

APPENDIX E

RELIABILITY ANALYSIS

1.0 INTRODUCTION

The MTBF resulting from the reliability prediction given here was based on the procedures of the Military Standard Handbook, MIL-HDBK-217B.

The reliability analysis is based on the following conditions:

1. The Tracking Receiver, and the Digital Antenna Control Unit were assumed to operate at an ambient temp of 35°C and in a ground-benign environment.

2. The Drive Racks, Motor Controllers, and associated equipment were assumed to operate at an ambient temp of 50°C and in a ground fixed environment.

2.0 ASSUMPTIONS

As in all reliability predictions, many assumptions were made in the course of this analysis. The following is a partial list which details the most significant assumptions made which have not been treated in detail in this technical note. The ordering of the list is random.

°Every part in each assembly which was considered to be in the Prime Path was taken into account for the reliability calculation.

- Every assembly in the system was considered to be operating on a 100% duty cycle. This is considered to be a conservative approach, since many of the assemblies do experience long idle times quite frequently.
- Ambient temperature is maintained at 35°C for control units and 50°C for the drive cabinet. Cooling techniques are based on conduction, radiation and free convection.
- PCB assembly is high quality and performed using complete inspection and test procedures.
- Power supplies have overvoltage and short circuit protection.
- Materials that are nutrients for fungi are not used.
- Metals are of the corrosion-resistant type and suitably treated to resist corrosion likely to be met in shipment and storage.
- Dissimilar metals are not used in intimate contact with each other.
- The system is designed to operate with an adequate margin of safety. Components are not operated above the electrical and thermal ratings recommended by the component manufacturer. In general, they are sufficiently derated in order to improve reliability.
- Wiring is cabled and secured with suitable lacing or binding material. All cables are securely attached to avoid damage and provide better maintenance access. Where

cabling "runs" are made across hinged parts, sufficient slack and protection is provided to prevent chafing or breaking of conductors as a result of normal flexing.

- The maintenance activity has complete knowledge of the fault symptoms of a failed assembly, as determined by operating personnel.
- All active corrective maintenance is accomplished by equipment replacement on the lowest replaceable unit (LRU) level. The lowest replaceable unit level is defined as the level of assembly that is wholly restored in order to actively maintain the system.
- All panels and assemblies are easily removable.
- Maintenance personnel are trained and motivated.
- All equipment is 100% spared to the lowest replaceable unit level.
- Spares, tools, test equipment and maintenance software aids (manuals and circuit schematics) are readily accessible to maintenance personnel.

3.0 FAILURE RATES

The following is a listing of failure rates for the individual units used in the servo system.

UNIT	F.R.	QTY USED
Down Converter	3.33	1
Beacon Receiver	19.92	1
Position Transducer	12.35	2
Motor Controller	37.15	4
Drive Cabinet Logic	72.45	1
Antenna Control Unit	122.95	1
Drive Motor	3.26	4

The prime method of operation is autotrack, with Memory Track or Program Track serving as a redundant path if the tracking signal is lost. Likewise, each axis has a redundant motor controller, motor pair so that the system remains operational even with the loss of 1 motor controller per axis.

The model developed by E. J. Einhorn, "Reliability Prediction for Repairable Redundant Systems", proceedings of the IEEE, February, 1963, shows that for redundant paths, assuming sufficient sparing to permit one hour repair, the failure rates of the individual parts in the redundant paths do not significantly contribute to the overall failure rate. Therefore, the system failure rate is the sum of:

Azimuth Position Transducer	12.35
Elevation Position Transducer	12.35
Drive Cabinet Logic	72.45
Antenna Control Unit	122.95
TOTAL FAILURE RATE	220.10

Since the MTBF is simply the reciprocal of the sums of individual failure rates:

$$MTBF = \frac{10^6}{F.R.}$$

$$\text{SYSTEM MTBF} = \frac{10^6}{220.10} = 4543 \text{ hours}$$

While the Antenna Control Unit, due to its complexity, is the major contributer to the failure rate, it is of modular design such that all boards except manual may be removed and still retain the capability for manual track.

Manual track is achieved by manually peaking the signal strength. Therefore, the manual track system failure rate is the sum of:

Beacon Receiver	19.92
Drive Cabinet Logic	72.45
Antenna Control Unit (Manual Position)	54.50
TOTAL FAILURE RATE	146.87

Resulting in a MTBF of $\frac{10^6}{146.87}$ = 6809 hours

4.0 AVAILABILITY

The availability of the control system to perform its tracking function is determined by considering the reliability of the system as well as the time required to repair a failure once it has occured. This information is obtained in the MTBF and the MTTR calculations respectively. Once these predictions have been made, the availability may then simply be calculated as follows:

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

The attached reports illustrate the calculations resulting in the following predictions for the servo control system:

MTBF = 4543 hours (AUTOTRACK)

MTBF = 6809 hours (MANUAL TRACK)

MTTR = .417 hour*

$$\text{Availability} = \frac{4543}{4543 + .417} = .99991 = 99.991\% \text{ AUTOTRACK}$$

$$\text{Availability} = \frac{6809}{6809 + .417} = .99994 = 99.994\% \text{ MANUAL TRACK}$$

*MTTR is estimated to be .417 hour or less. Due to the modular nature and suggested sparing of all replaceable cards and power supplies, actual replacement can be accomplished within 5 minutes. The 20 remaining minutes allotted to isolating the fault to a particular module is more than sufficient due to the software self check aids. In addition, the circuits are functionally packaged to aid in fault isolation.

5.0 CALCULATIONS

The backup for the calculated failure rates of the following units will be provided upon request.

ITEM	DESCRIPTION	FAILURE RATE
1.	93C-15 Antenna Control Unit	122.95
2.	63R-1 Down Converter	3.33
3.	43S-2 Beacon Receiver	19.92
4.	83MC-2 Motor Controller	37.15
5.	Drive Cabinet Logic	72.45
6.	Position Transducer	12.35